EARTHQUAKE FACTS AND FICTION

1. **WHAT IS THE DEFINITION OF AN EARTHQUAKE**?
An earthquake is the sudden, sometimes violent movement of the earth's surface from the release of energy in the earth's crust.

2. **WHAT CAUSES MOST EARTHQUAKES**?
Earthquakes are natural products of dynamic processes of our planet, called plate tectonics, which cause the earth's crust to bend slightly when subjected to great pressure. When the stress or pressure on the crust exceeds the strength of its rocks, the crust breaks and snaps into a new position, releasing energy in the form of vibrations that travel through the earth and on its surface. These vibrations are seismic waves that cause the ground motion called earthquakes.

3. **WHERE ARE EARTHQUAKES LIKELY TO OCCUR**?
Within the crust are fractures, known as faults, along which two large crustal blocks have slipped or moved against each other. Faults are zones of weakness in the earth's crust that may or may not be seismically active, depending on the stresses placed upon them by tectonic forces. Faults that are under high stress tend to rupture again and again over time, producing earthquakes of varying magnitudes.

4. **HOW MANY EARTHQUAKES OCCUR EACH YEAR**?
Over a million earthquakes happen every year, most of which are too small to be felt. The table below shows the average frequency of different earthquake magnitudes.

Description Magnitude Frequency per year:

Magnitude	Frequency
Great 8.0+	1
Major 7.0 - 7.9	18
Large (destructive) 6.0 - 6.9	120
Moderate (damaging) 5.0 - 5.9	1,000
Minor (damage slight) 4.0 - 4.9	6,000
Generally felt 3.0 - 3.9	49,000
Potentially Perceptible 2.0 - 2.9	300,000
Imperceptible less than 2.0	600,000

(From Earthquakes and the Urban Environment, V. 1, G. Lennis Berlin, 1980)

5. **HOW MANY EARTHQUAKES OCCUR EVERY MONTH? DAY? MINUTE**?
Using the previous table by G. Lennis Berlin:
Per month – Approximately 79,678
Per day – Approximately 2,620
Per minute – Approximately 2
Per second – Approximately 1 every 30 seconds
Of these, only a few cause damage. Earthquakes are very common natural events.

6. **HOW MUCH ENERGY IS RELEASED IN AN EARTHQUAKE**?
Earthquakes release a tremendous amount of energy in an instant, which is why they can be so destructive. The table below shows magnitudes with the approximate amount of TNT or dynamite needed to release a similar amount of energy.

Magnitude	Approximate TNT Energy Release	Atomic Bomb
4.0	1,000 tons	1 KT
5.0	32,000 tons	32 KT
6.0	1,000,000 tons	1 MT
7.0	32,000,000 tons	32 MT
8.0	1,000,000,000 tons	1000 MT
9.0	32,000,000,000 tons	32,000 MT

(Source of Data for Magnitude to TNT Comparison: USGS Alask Seismic Studies Project)

Historically, the measurement of the expected explosive force of modern bombs was based on the explosive force of specific weights of Trinitrotoluene, commonly known as TNT.

Therefore, once the atomic bomb was developed, its explosive power was compared to the equivalent weight of TNT.

The explosive force of a one-ton bomb is equivalent to 2,000 pounds (2 Kilotons – KT) of TNT. This means that a one-megaton (MT) atomic bomb is equivalent to 2 billion pounds (1 million tons) of TNT.

Note: The atomic bomb dropped on Hiroshima was only about 13 Kilotons (13 KT).

7. **HOW DEEP DO EARTHQUAKES OCCUR**?
Earthquakes take place in the crust or upper mantle, which ranges from the surface to about 800 kilometers deep (about 500 miles).

8. **DOES THE GROUND REALLY OPEN UP AND SWALLOW PEOPLE**?
This is an earthquake myth. Cracks and fissures appearing in the ground are a common effect of earthquakes. Most of these are narrow and shallow. In very large earthquakes changes in the level of the land can result in larger cracks that can cause a lot of damage to buildings, but people and buildings do not disappear into the earth.

9. **WHY ARE THERE MORE EARTHQUAKES IN SOME PLACES THAN OTHERS**?
The surface of the earth is divided like a jigsaw puzzle into giant pieces called tectonic or crustal plates. Due to the forces of plate tectonics, these giant plates move very slowly over partially melted rock called the mantle.

As the plates move, they interact with each other in different ways: some move into each other (plate to plate collision), some move away from each other (spreading centers), or one slips beneath another (subduction).

The edges or boundaries of the plates are therefore under huge stresses, and have the most earthquakes. About 95% of all earthquakes occur on the active plate boundaries. California, Alaska, Japan, South America, Taiwan, and the Philippines are all on plate boundaries, and have many earthquakes. The remaining 5% are in areas of the plates far away from the boundaries. These are called mid-plate or intra-plate earthquakes and are much less understood than plate boundary earthquakes.

10. **WHICH STATE HAS THE MOST EARTHQUAKES**?
Alaska has more earthquakes per year than the combined total for the rest of the United States. There are as many as 4,000 earthquakes recorded there annually. Alaska is on a subduction zone, where one tectonic plate is sliding under another.

11. **WHAT WAS THE LARGEST EARTHQUAKE IN THE UNITED STATES**?
On Good Friday, March 27, 1964, the great Alaska earthquake struck, and shook the ground for approximately seven minutes. The original magnitude of 8.3 was determined using the Richter Scale, even though scientists knew the Richter Scale was not accurate for very large earthquakes. The magnitude was recalculated years later with more sophisticated methods and established at 9.2. The earthquake was responsible for 115 deaths, with most due to the tsunami that was generated.

The surface of the ground was raised or lowered as much as 2 meters (6.5 feet) in some areas and 17 meters (approximately 56 feet) in others. The length of the ruptured fault was between 500 and 1,000 kilometers (310.5 and 621 miles), and the amount of energy released was equal to about 64 billion tons of TNT.

12. **WHERE WAS THE LARGEST EARTHQUAKE IN THE LOWER FORTY-EIGHT STATES**?
It was not on a plate boundary, but in a mid-plate or intra-plate region, far away from the active earthquake zones in the western U.S.

Three earthquakes occurred on December 16, 1811, January 23, and February 7, 1812, with estimated magnitudes of 7.5, to 8.2. Known as the New Madrid earthquakes (after a small southern Missouri town that was completely destroyed and later rebuilt in a different location). These three earthquakes released more seismic energy in a short time span that any in known history. The 8.2 event was about the equivalent of the release of energy from about 77,000 Hiroshima bombs going off underground all at once.

Felt over 2 million square miles, the New Madrid earthquakes caused extensive damage to structures throughout the region and affected a land area greater than any other in known U.S. history. In fact, the ground shaking caused church bells to ring in Richmond, Virginia, and Charleston, South Carolina. The earthquakes were felt as far away as Boston, Massachusetts, Washington, D.C. and southern Canada.

The earthquakes raised or lowered the ground surface several feet, created Reelfoot Lake in northwest Tennessee, several smaller lakes, and formed waterfalls on the Mississippi River (which caused a limited part of the river to flow backwards for a short time). It is believed there were fewer than 100 deaths, because the population in the central U.S. at that time was small.

13. **WHAT WAS THE GREATEST NUMBER OF PEOPLE KILLED IN ONE EARTHQUAKE**?
An earthquake in China in 1556 killed approximately 830,000 people.

14. **DO ALL LARGE MAGNITUDE EARTHQUAKES RESULT IN GREAT DEATH AND DESTRUCTION**?
No. The destructiveness depends on many factors. Large earthquakes are commonly in remote, unpopulated areas, and are not destructive. Others are in areas with well-constructed buildings and a prepared population.

Factors along with magnitude, that determine damage and deaths, include population densities, type and density of building construction, local geologic conditions, distance from the epicenter, earthquake depth, the length of shaking, the presence of appropriate building codes, and the degree of earthquake preparedness in a region.

The following table shows some major earthquakes around the world, and the number of deaths they caused. Note the difference in the number of deaths from similar sized earthquakes in the U.S. and other countries.

Year	Date	Region	Deaths	Magnitude
1982	06-11	Southern Iran	3,000	6.9

1983	12-13	Yemen	28,000	6.0
1985	10-30	Turkey	1,342	6.9
1989	09-19	Mexico	10,000	7.0
1989	12-07	Armenia	25,000	6.9
1989	10-17	Northern California	67	7.1
1990	06-20	Iran	40,000	7.7
1993	09-29	Southern India	9,748	6.9
1994	01-16	Southern California	65	6.8
1995	01-16	Japan	5,502	6.9
1999	08-17	Turkey	17,118	7.4
1999	09-21	Taiwan	2,297	7.6
2001	01-26	India	19,988	7.7 3
2002	03-25	Afghanistan	1,000	6.1
2003	05-21	Northern Algeria	2,266	6.8
2003	12-26	Southeastern Iran	26,200	6.6
2004	12-26	Sumatra (EQ & Tsunami)	283,106	9.0
2005	03-28	N. Sumatra, Indonesia	1,313	8.7
2005	10-08	Pakistan	80,371	7.6

Note:

2002	11-03	Denali, Alaska	0	7.9
2003	03-17	Rat Islands, Alaska	0	7.1
2003	11-17	Rat Islands, Alaska	0	7.8

15. **WHEN WAS THE FIRST INSTRUMENT INVENTED FOR DETECTING EARTHQUAKES**?

In 132 CE, Zhang Heng, a Chinese philosopher, invented a beautiful and simple device for detecting earthquakes. The instrument was a large bronze jar (2 meters or 6.5 feet in diameter) with a central pendulum inside. Decorating the outside of the jar was a series of dragonheads connected to the pendulum, each with a ball inside a hinged mouth. Directly beneath each dragonhead, on the surface of the stand holding the jar, was a bronze toad, head up and mouth open, ready to receive a ball from the dragon 's mouth.

During an earthquake, ground motion would move the pendulum and cause one or more of the balls to fall from a dragon's mouth to a frog's mouth. The direction of the earthquake was indicated by the orientation of the dragonheads that dropped the ball.

The instrument was apparently sensitive enough to respond to shaking too small to be felt, as it detected an earthquake over 600 kilometers (372 miles) away, news of which arrived several weeks later. Earthquake detectors are mentioned in later Asian manuscripts, but were not invented in the west until centuries after the Chinese instruments.

16. **HOW ARE EARTHQUAKES MEASURED TODAY**?

The scientific measurement earthquake magnitude is done with information from instruments called seismometers, which record ground motion from earthquakes. At universities and research institutes in the U.S. and other countries, computers constantly record data from seismometers in place throughout the world. From seismic records, scientists can calculate the magnitude, location, and depth of an earthquake.

Calculations are made from many different seismic stations, both close to and far away from the earthquake source, to ensure as much accuracy as possible in determining the magnitude. Because of the amount of data that needs to be analyzed, the most accurate magnitude can take time to determine, so the first reported size of an earthquake is referred to as "preliminary magnitude." The magnitude for any earthquake is the same regardless of where it was felt or recorded.

17. **WHAT IS THE RICHTER SCALE**?
Charles Richter developed his scale in 1935 to determine the magnitude of moderate earthquakes in southern California. The Richter Scale became the common magnitude term for many years, despite the fact that it was not accurate for earthquakes above magnitude 7 or for those recorded at distances greater than 600 kilometers (372 miles).

18. **WHY DO SCIENTISTS NO LONGER USE THE RICHTER SCALE**?
With the development of increasingly sophisticated seismometers and earthquake data, the science of seismology has advanced, leading to more accurate methods to determine magnitude. For this reason, scientists no longer commonly use the Richter Scale, but instead use a variety of other, more accurate scales.

Due to the number of complex methods now used to determine earthquake magnitude, the U.S. Geological Survey has adopted the policy of simply using "magnitude" to describe the size of an earthquake. The use of this term is becoming increasingly familiar to the public, although Richter magnitude scale is still used in many news reports and articles because it is the measurement that commonly was used in the past.

19. **WHAT IS THE MODIFIED MERCALLI INTENSITY SCALE**?
Another nonscientific, but useful, way of measuring the effects of earthquakes is to estimate the degree of shaking, stated in terms of some intensity scale that shows expected damage over a specific geographical region. Projected shaking intensity maps are useful tools for scientists, emergency management officials, building officials, planners, engineers, etc., because they show the effects on infrastructure in the areas that could be adversely affected by an earthquake.

The Modified Mercalli Intensity Scale (MMI) is the measurement tool most commonly used to project damages in geographical regions today. The MMI uses Roman numerals a range of one to twelve as a scale to organize narrative descriptions of increasingly greater earthquake intensity effects. The descriptive narratives explain what people likely will feel and the kind and amount of damage they might observe. The greatest intensity will be felt closest to the epicenter usually, with smaller intensities farther away.

20. **WHAT IS THE DIFFERENCE BETWEEN AN EARTHQUAKE PREDICTION AND FORECAST**?
Scientists still have much to learn about the behavior of earthquakes and their recurrence rates.
In fact, there really is no way to accurately predict earthquakes (the naming a specific date, location, and magnitude for a seismic event). However, forecasts have been calculated for different areas of the United States. A forecast assigns a series of probabilities with ranges of years and magnitudes.

Even though an earthquake has been assigned a probability for occurrence, it does not mean one will necessarily happen within the forecast time span because probabilities are only rough estimates with potentially wide margins of error.